Shoot! Foiled Again!

Using Chemicals To Discourage the Pine Shoot Beetle

Meet the Scientists

Dr. Poland: ◂ My favorite research experience was working in China. The experience was so different from the United States. Many local farmers and children came to help us. The area had very poor farmland with trees planted to protect the area from wind. The children were so eager to help us. They collected beetles for us and stored them in wire bicycle baskets.

Dr. De Groot: ▸ My favorite science experience is working outdoors to set up and run my experiments so that I can discover new facts about trees and forest insects.

Dr. Burke: ◂ In the 1980s, I created a special chemical in a chemistry lab. This was a powerful *pheromone* that is a very strong attractant for a particular *species* of beetle. This beetle causes severe damage to logs that will be cut into lumber. Tiny amounts of the pheromone that I made were formulated into lures, and the lures were placed in funnel traps similar to the one you see in this photo. One month later, we inspected the traps, which we had placed at lumber mills. Many traps contained more than 25,000 beetles and virtually no other insects. At one mill, we caught over 12 million beetles in 1 year. Here was science in action! It was truly amazing that the chemical, made in the sterile environment of a laboratory, could cause such a strong effect in the field. This photo was taken in China, where I was studying the pine shoot beetle. I am the person on the left.

◂ Dr. Wakarchuk: One of my most exciting moments as a chemist occurred when we took the first pheromone lures into the field during a beetle flight. It had taken several months of work in the laboratory to create the beetle pheromones out of chemicals. When we brought the lures out, the tiny beetles were landing on our clothing and bouncing off our heads. Chemistry really came alive when I realized that our clothing had small amounts of pheromone on it, and that the beetles were strongly attracted to this small amount of pheromone. It was very satisfying to know that all the chemistry work was done right and that the beetles weren't able to distinguish people contaminated with *synthetic* pheromone from their normal host (a freshly killed tree infested with beetles). In this photo, I am holding a multifunnel trap that is often used to trap bark beetles. A multifunnel trap was used in this research, as you will learn.

Dr. Nott: ▸ My favorite science experience had to be meeting Dr. Roberta Bondar who worked at the Great Lakes Forestry Centre when she was a student attending university. Dr. Roberta Bondar was the second Canadian and the first Canadian woman to go into space aboard the space shuttle *Discovery*. Shortly after her historic flight, she visited our Centre to give a firsthand account of her experience. It was awesome!! Here is a photo of me setting up one of the traps for the pine shoot beetle. The pine shoot beetle emerges very early in the spring so our traps had to be installed while snow was still covering the ground (and me).

Dr. Haack: ◂ My favorite science experience happened in ancient history (1975–1978) when I was working as a forester in the Peace Corps in Guatemala in Central America. There was a massive outbreak of pine-infesting bark beetles that killed millions of pine trees in Guatemala. It was that experience that made me want to study forest insects, and so after returning to the United States in 1978, I went to graduate school at the University of Wisconsin to study forest *entomology*.

Glossary:

pheromone (**fair** uh mon): A chemical given off by certain animals to attract mates, mark trails, etc.

species (**spe** sez): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

synthetic (sin **theh** tik): Made by putting together chemicals rather than using natural products.

entomology (**en** to **mul** o je): The study of insects.

disperse (di **spürs**): To scatter or spread in all directions.

habitat (**hab** uh tat): Environment where a plant or animal naturally grows and lives.

ecosystem (**e** ko sis tem): Community of plant and animal species interacting with one another and with the nonliving environment.

native (**nat** iv): Naturally occurring in an area.

invasive (in **va** siv): Tending to spread or infringe upon.

resource (**re** sôrs): Something that takes care of a need.

phloem (**flo** em): Tissue that transports nutrients from the leaves to the rest of the plant.

larva (**lär** vuh): Wormlike feeding form that hatches from the egg of many insects.

pupa (**pu** pa): Intermediate stage of insect growth between larva and adult. Pupae (**pu** pe) is the plural.

emit (e **mit**): To throw out or eject.

population (päp yoo **la** shun): The whole number of individuals of the same type occupying an area.

broadleaf (**brôd** lef): Flat broad leaves.

control (kän **trol**): Something used for comparison when checking the results of an experiment.

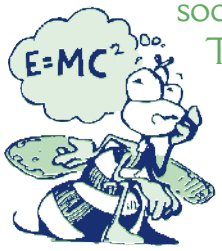
average (**av** rij): The usual kind or amount. The number obtained by dividing the sum of two or more quantities by the number of quantities added.

Pronunciation Guide

a	as in ape	o	as in go	ü	as in fur
ä	as in car	ô	as in for	oo	as in tool
e	as in me	u	as in use	*ng*	as in sing
i	as in ice				

Accented syllables are in **bold.**

Thinking About Science



Science is a process of discovery that helps society by answering questions. The questions involve a specific problem that, when solved, will improve something that society values. Let's take this research as an example. Society places a value on healthy pine trees for a number of reasons. In this study, the scientists studied pine trees that people were going to use during the winter holiday season to decorate their homes.

When an insect attacks and damages or kills a large number of holiday pine trees, society considers this a problem. Fewer holiday trees might mean higher prices for the people who want to buy them. Trees damaged by insects might also be less attractive. The problem can be stated as a question, such as "What can be done to prevent an insect from attacking pine trees?" Scientists can ask many different questions that stem from the same problem. In your own words, develop another question that scientists could ask, based on the problem of insects attacking pine trees.

Thinking About the Environment

You know that plants have fragrances. Think about the fragrances of flowers and newly mown grass. Scientists call these fragrances volatiles (**vol** uh tl̩z). They are released when a chemical inside the plant is exposed to air. When exposed to air, the chemical evaporates, which causes it to be *dispersed* in the air. Many plants have volatiles that humans cannot smell. Insects, however, can smell many of these volatiles. Most insects smell volatiles using special cells on the surface of their antennae. The volatile attracts the insects to the plant. They can then use the plant for food, as a place to lay their eggs, or as *habitat*. Name one example of an insect that uses its antennae to find food.

In this research, the scientists were interested in finding out how to prevent a particular insect from being attracted to pine trees. In this case, when the insect smells the volatile and finds the pine tree, its use of the tree damages the tree and can even kill it.

Introduction

In a healthy *ecosystem*, plants and animals have adapted together to keep the whole system healthy. Healthy ecosystems are usually made up of *native* plants and animals. When a nonnative plant or animal invades a native ecosystem, the ecosystem can be damaged. A nonnative plant or animal, called an *invasive* species, causes damage by reproducing so much that it uses too many native *resources*.

The pine shoot beetle (**figure 1**) is an invasive species in the Great Lakes region of the United States (**figure 2**). The pine shoot beetle was brought to the United States from Europe, Asia, and northern Africa. This beetle damages or kills pine trees by using the trees for reproduction and feeding. Female adult beetles bore a hole into the bark of a pine tree along the roots, where they breed with a single male. The females then bore into the *phloem* of the tree, where they lay their eggs (**figure 3**). When each egg hatches into a *larva*, the larva further tunnels in the phloem, where it becomes a *pupa*. When the pupa becomes

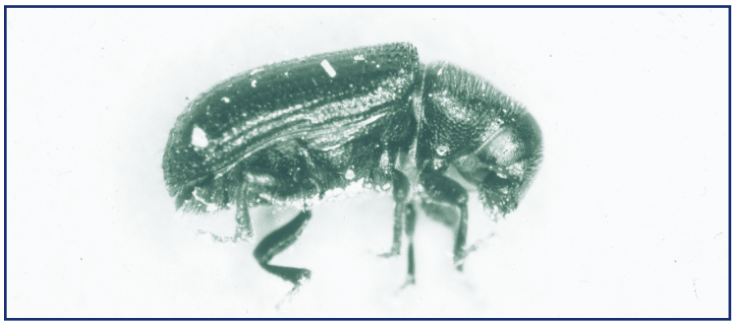


Figure 1. Pine shoot beetle.

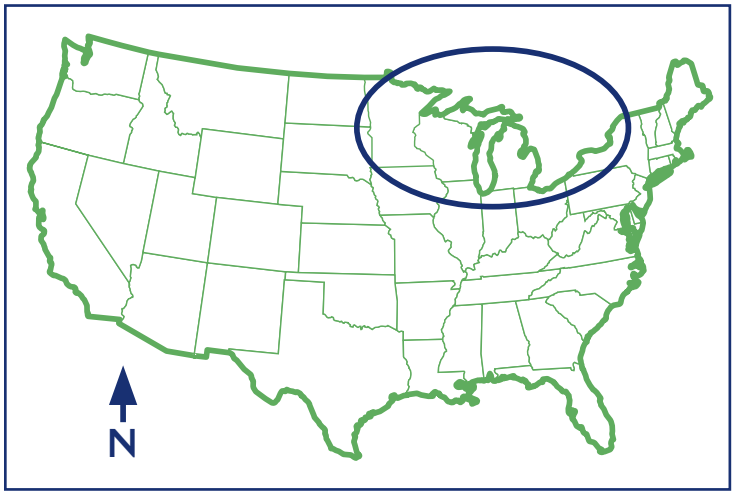


Figure 2. The Great Lakes region of the United States.

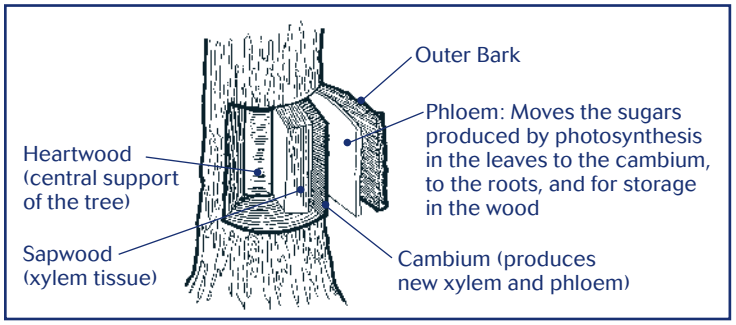


Figure 3. The phloem of a tree.

an adult, it emerges from the tree. These young adult beetles then feed on the healthy shoots of the pine tree (**figure 4**). As you can imagine, when many beetles reproduce in one tree, the tree can be damaged or killed.

As you read in "Thinking About the Environment," insects are attracted to plants such as trees by smelling their volatiles. Think about what might happen if too many pine shoot beetles are attracted to a particular pine tree. Soon, the tree would have too many beetles, and the additional beetles' needs for breeding and eating could not be met. Something interesting occurs to keep this situation from happening. The beetles *emit* a special type of pheromone that other beetles detect. This chemical, called a verbenone (**vür** buh non), tells other beetles that the area is overcrowded. As more beetles attack a tree, the rising amount of verbenone discourages other beetles from using that tree.

Unfortunately, verbenone does not discourage other beetles until so many beetles are present that the tree is damaged or killed. The rising amount of verbenone protects the beetle *population*, but it does not protect the tree. The scientists in this study wanted to find out if chemicals such as verbenone could be used to keep pine shoot beetles from attacking trees in the first place. They also wanted to know if other volatiles, such as those from *broadleaf* trees, would discourage pine shoot beetles from attacking pine trees. The scientists thought the use of broadleaf volatiles might fool the beetles into thinking the pine trees were not really pine trees, but broadleaf trees.

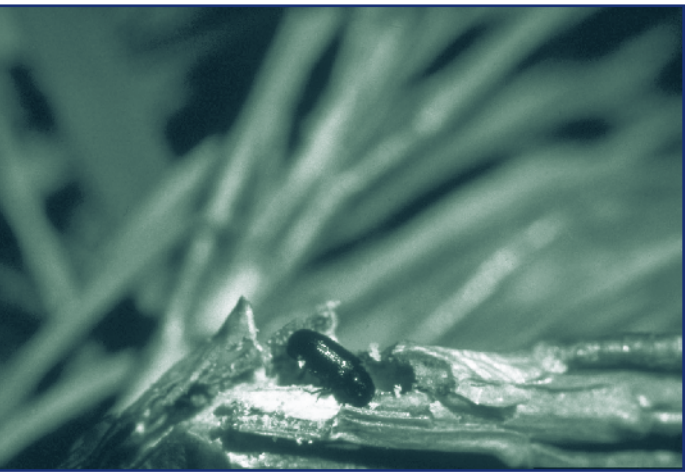


Figure 4. A young pine shoot beetle feeding on a pine shoot.

Photo courtesy of Steve Passoa, USDA Animal and Plant Health Inspection Service, http://www.forestryimages.org.

Reflection Section

- Explain in your own words how verbenone protects the beetle population but not the pine trees.
- In your own words, ask one question the scientists wanted to answer.

Method

The scientists conducted two identical experiments. One was done in southern Ontario, Canada, and the other in southern Michigan (**figure 5**). They conducted the

Figure 5. The study sites were in southern Ontario and southern Michigan.

experiments in holiday tree plantations of Scots pine. In these plantations, trees are planted in rows and pruned into the popular cone shape. You can see some of the trees in Dr. Nott's photo at the beginning of this article. The scientists used traps to catch the pine shoot beetles. (See the scientists' photos at the beginning of this article.) They baited all but one trap with Scots pine volatiles and also included other chemicals on some traps to discourage the beetles (**figure 6**).

Trap number	Chemicals in each trap	Purpose of trap
Traps 1–3	No chemicals	*Control*
Traps 4–6	Scots pine volatiles. The Scots pine volatiles should attract the beetles.	To attract beetles. This is a test to find out whether the Scots pine volatiles attract the beetles.
Traps 7–9	Scots pine volatiles plus broadleaf volatiles. The Scots pine volatiles should attract the beetles, and the broadleaf volatiles should discourage the beetles.	To attract and discourage beetles. This is a test to find out whether the broadleaf volatiles discourage beetles.
Traps 10–12	Scots pine volatiles plus broadleaf volatiles plus verbenone. The addition of verbenone, when compared with traps 7–9, will tell the scientists whether verbenone further detracts beetles.	To attract and discourage beetles. This is a test to find out whether the verbenone adds to the broadleaf volatiles.

Figure 6. Traps were set containing a combination of volatiles and other chemicals.

The scientists repeated the placement of the 12 traps in 10 separate areas of each of the two pine plantations.

Number Crunches

- How many total traps were set on each pine plantation? How many traps were set overall?

The scientists collected the beetles from the traps twice each week for almost 6 weeks. They identified the sex of each beetle and counted the number of beetles according to its sex. The scientists then compared the number of beetles collected in each trap.

Reflection Section

- Explain in your own words what the scientists might learn from each of the four sets of traps (from figure 6).
- Why do you think the scientists repeated the experiment 10 times on each plantation?

Findings

The results of the experiment are shown in **table 1**.

As you can see, there were differences in the average number of beetles captured in Michigan and in Ontario. The pattern for each set of traps, however, is similar. In both Michigan and Ontario, the number of beetles being trapped was much higher when the Scots pine volatile was used than when it was not used. (Compare the first and second set of traps for each place.) Regardless of the chemicals used, the average number of beetles trapped was much lower than when no chemicals except the volatiles were used. (Compare the second set of traps in each place with the third and fourth sets.) When